VALIDATION OF A PILOT MANAGEMENT SCHEME FOR CERAMIC TILE MANUFACTURING

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1. ABSTRACT

A pilot scheme has been established that defines and demonstrates implementation of control and process optimisation in ceramic tile manufacturing, based on:

- A **single database**, accessible from different levels.
- **Individual splitting of production batches** and access to corresponding process data.
- Calculation of **cost and net margin** attributable to each production batch.
- Obtainment of **benchmark references** to identify the best batch from the point of view of economic margin.
- When **significant deviations in quality** occur, the ability to trace and identify the likely operating variables causing such fluctuations.
- Identifying costs and establishing **balances between cost and quality**.

Following the specifications set out by the management of **Azulejera Alcorense,** the scheme is currently being implemented in a real-life scenario, by matching the pre-determined conditions to the specifics of this particular case in order to determine its technical validity and the foreseeable incentives to be obtained from it.

To that end, the information provided by the company plus the experience gained in developing the pilot scheme will be used to produce a written specification for rolling out the system, which includes:

- The technical specifications required to collect relevant data at each different stage in the process.
- The digital infrastructure required.
- The operating variables needed.
- The specific calculations required
- An estimation of the incentives to be gained.

As a final summary, we are proposing a change of culture to bring **digitisation** into the operations, which to date has only been applied in Finance (ERPs).

2. BACKGROUND

The motivation to research the contents of this paper stems from two main events:

- Firstly, from the author's personal experience of how the Petrochemical, Pharmaceutical and Pulp & Paper industries have developed. In fact, all of those sectors have always employed the most suitable technology for their processes but in the 1990s, they identified a need to evolve in order to have a **more comprehensive view in real time of the entire process**. In the author's opinion, such technology is missing from the tile manufacturing sector, thus impeding the increasingly necessary optimisation of the production process.
- Secondly, the current situation in the tile manufacturing industry shows a sector immersed in a complicated environment in terms of both competition and costs. It is therefore obliged to produce the highest standards of quality and to launch new products at minimal cost given the standard of quality.

In order to address this shortcoming, the experience of other sectors that have already gone through such circumstances using available support technology needs to be applied in combination with the sector's specific requirements.

For technological support, we turned to Honeywell, whose worldwide reputation as leaders in automation and control has been strengthened by its recent acquisition of Matrikon, thus affording it the best technology for communications with any primary control units, namely, PLCs or, where applicable, SCADA. These items are the ones that control the machinery used in tile manufacturing.

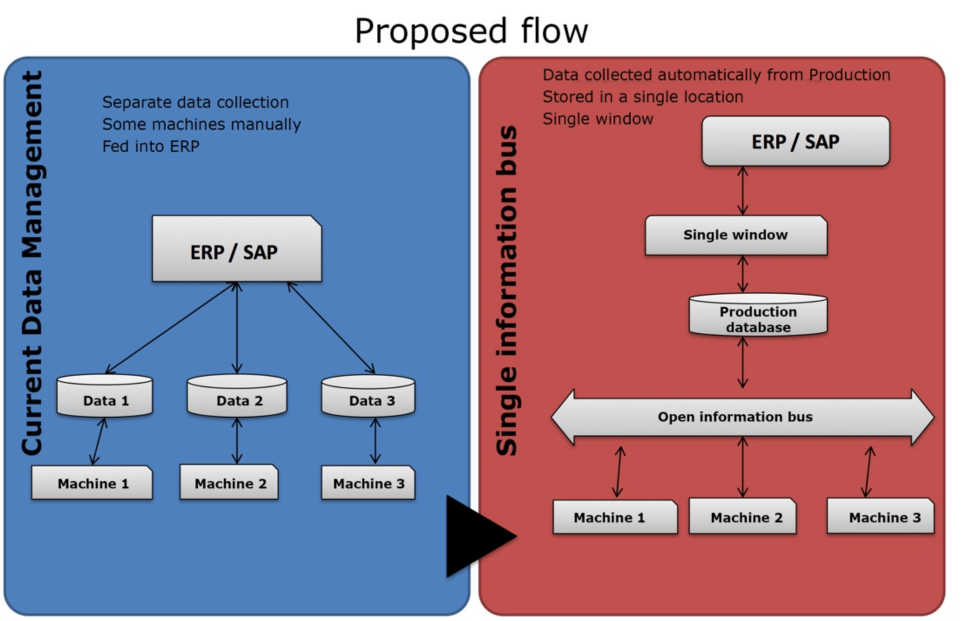
Furthermore, in order to have first-hand input from the industry, the authors contacted the Instituto de Tecnología Cerámica (ITC), and a work team was set up comprising the author and his partner together with Juan Boix and Nestor Pascual from ITC. This is the team that structured the pilot scheme, the validation of which is the subject of this paper.

3. PROPOSED SOLUTION

3.1. 1. INFRASTRUCTURE

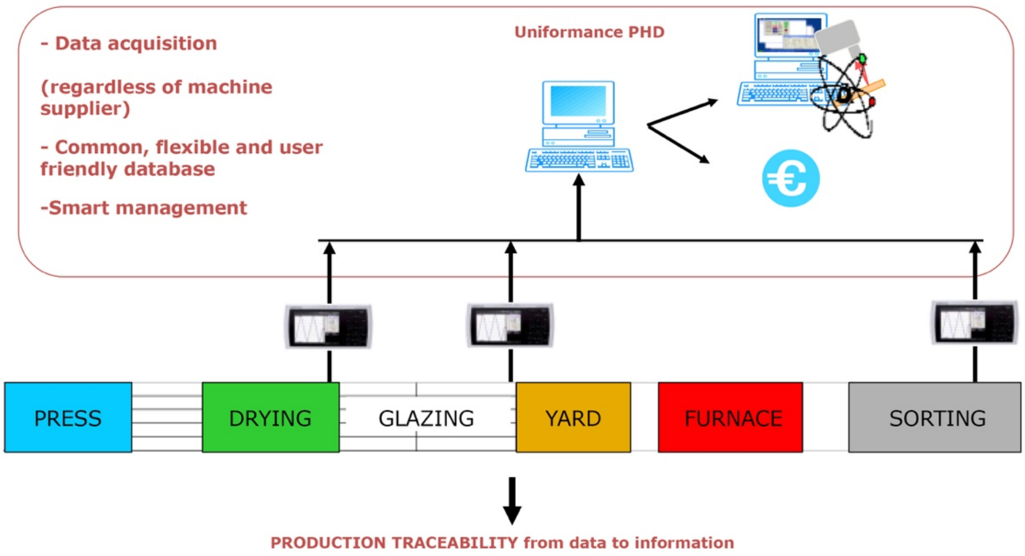
In view of the background facts outlined above, we propose a **change of operating strategy based on a different flow of information.** The following chart provides a diagram of the proposal, indicating on the left the scheme normally used, in which each machine is stored and consolidated in the ERP system. In our proposed solution, the database is fed from **a single information bus**, which allows the entire process to be viewed in a single window.

The database where all the data from the various process machines are collected constitutes the proposed solution that feeds a database, enabling the entire process to be monitored in a single window. This database is called the "PHD Uniformance Process History Database", which has been proven in over a hundred thousand industrial facilities.



Based on the above structure, a pilot has been defined to describe and demonstrate ceramic tile manufacturing control and optimization, which can be graphically displayed as follows:

Prototype - Infrastructure



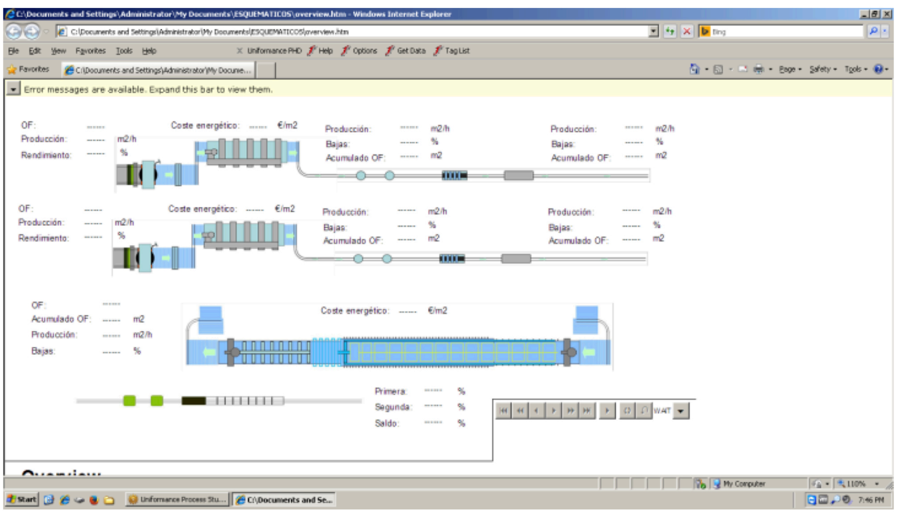
Once the infrastructure that connects the various machines with the bus and the server has been installed, each process variable can be accessed and even combined with data from other sources such as manual inputs or data from the specific ERP installed, where necessary.

Therefore, server access enables us to:

- Integrate process data in real-time.
- Draw up analysis, calculations, graphs
- The addition of variables is individually configurable.
- It allows for a graphics interface.

By way of an example, the illustration below shows a graphic interface:

Prototype Interface



3.2. CALCULATION OF COSTS AND MARGINS AND PROCESS OPTIMISATION

This new, industrially proven technology solution can enable the sector to cope with new demands from the market. In the first phase, it provides a full view and list of production values. Moreover, apart from the data captured directly at production machinery, it can perform first-level applications by performing calculations using the data combined with historical values, which thus enables production to be integrated with business objectives.

Indeed, the tile manufacturing process has its own special characteristics in that it is a **batch process albeit discontinuous,** because, at the end of certain stages in the process like Kiln Firing, there is an intermediate storage stage. The solution we propose includes something we truly believe to be **novel** and extremely useful for optimising the manufacturing process – it manages to identify and isolate production batches according to process variables, costs, margins, etc. This represents a significant breakthrough, not only because it displays a full overview of the production, as mentioned above, but also because that view can be broken down by Manufacturing Orders. That then enables **significant progress to be made in terms of improving and optimizing the process** compared to the current method of handling partial data from the machines in service listed by parameters such as months, days, etc., which makes it very difficult to subsequently split the data by production model, format, etc.

In contrast, this technology provides the process variables, manual inputs and values in the ERP system, while it also allows first-level (mathematical) and second-level (programming) calculations to be made. All these variables at different levels are related to the variable known in control language as "Time Stamp"; this variable, coupled with identification of the start and end of each stage (drying, pressing, firing, etc.), which together form the Manufacturing Order (batch), allows us to perfectly delimit the environment regarding process variables and other variables, including calculations, stored as calculated variables.

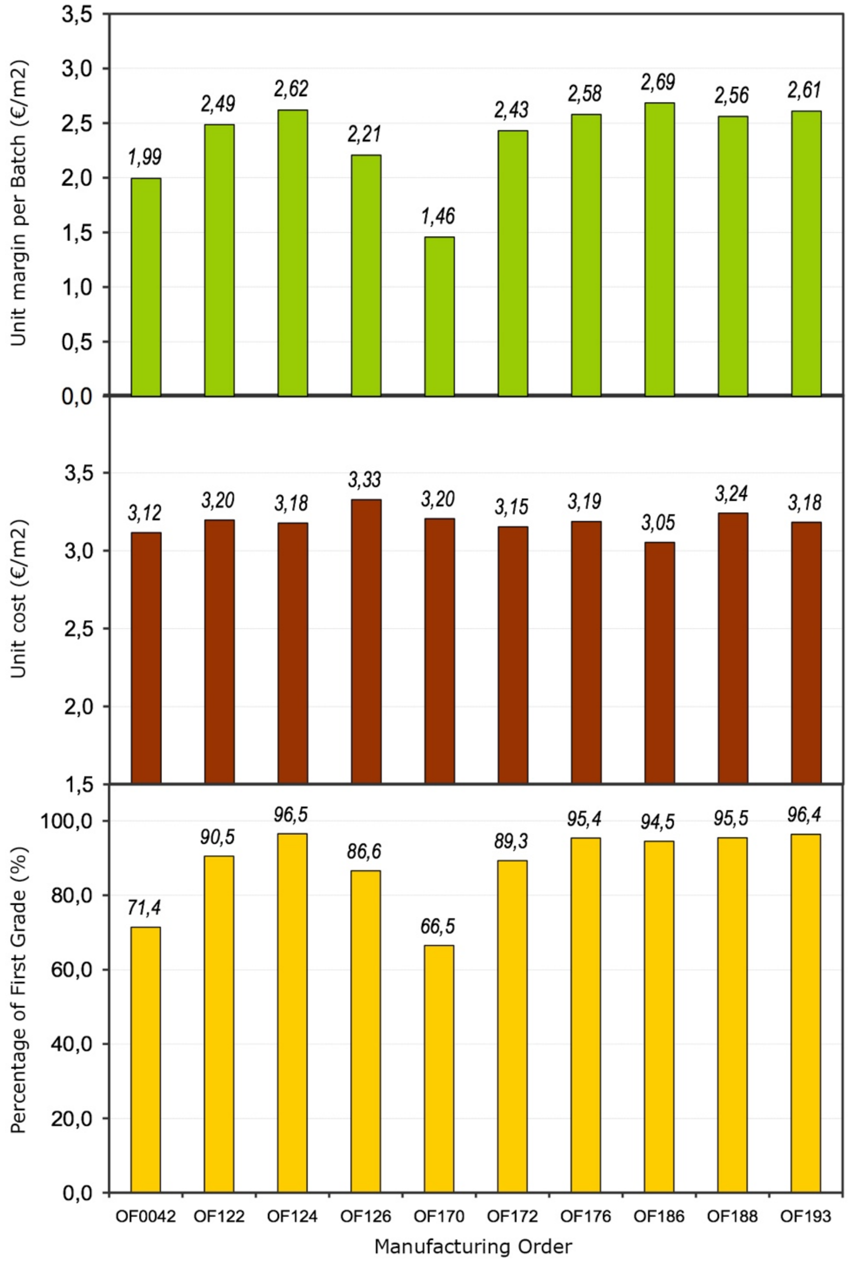
This individualization enables "live" and post-production analysis of the Manufacturing Orders. In our pilot, we identified the specific, average and total values for the entire batch of both process values and the variables we are interested in calculating. That gives us:

- Unit cost values for the Manufacturing Order.
- Net margins attributable to those costs.
- Quality values achieved.

These values are displayed in bar graphs for different Manufacturing Orders (Batches), which reveal how values are dispersed both in terms of Cost and, more importantly, Gross Margin per Batch. In our case, we have made a very simple formula but one that we deem to be perfectly valid for comparison.

Gross margin = (Top grade * Sale Price + Second grade * Sale Price) - Variable Costs.

In a real-life case, this can be tailored to reflect the entire complexity, including structural costs, if required.



If the highest margin in OF186 is taken to be the Optimal Batch and is then compared to the other batches in both absolute terms and as a percentage, the outcome is:

- Operating variables throughout the batch.
- Averages, deviations in the Batch.
- Calculated variables, costs, margins of the Batch.

This technology can therefore be used to establish benchmarks for each model and format to be manufactured. In the pilot, to serve as an example, it was reduced to just one and it is assumed that if production is carried out in conditions close to the benchmark, the gross margin obtained will be closer to **2.69 €/m^2** than **2 €/m^2**. Thus, we can infer that the economic Incentive achieved would be **3450 €/day** for a standard production output of **5000 m^2/day**, which in one year would mean about **€1 million**.

Furthermore, the stored data can also be used to make comparisons between production orders involving different formats. Thus, it can be deduced from the pilot data that the average margin in the 120x60 format is **€7.85 per m^2**, whereas the average margin for the 60x60 format is **€5.95 per sq. metre**.

This comparison should be especially useful both for programming and planning manufacturing and defining business strategy. Based on the data from the pilot that will be compared to actual manufacturing data in the plant, the production costs of the larger formats are easily offset by their higher sales prices, which leads to significantly improved gross margins.

Obviously, directing production and sales towards formats and models that generate higher gross margins can lead to significant incentives. Even if an increase of just 1 €/m^2 were obtained on 20% of the production, the annual Incentive would be:

5000 m^2/day * 300 day/year * 1 €/m^2 * 20% = **€300,000 per year**

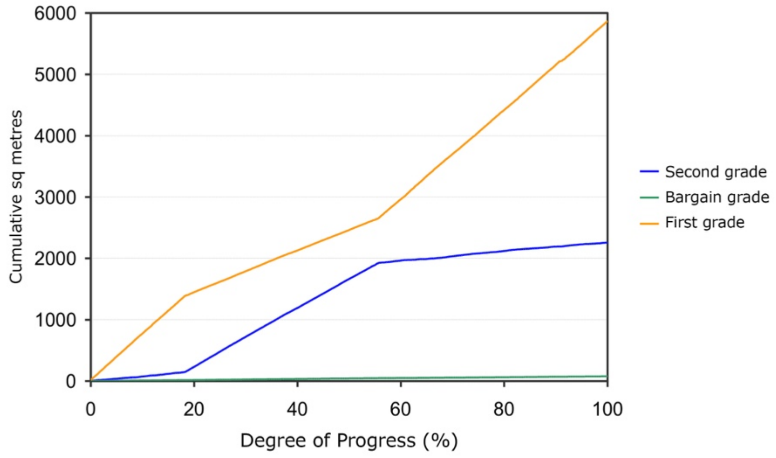
3.3. PRODUCTION TRACEABILITY

So far, this technology has enabled us to analyse the entire set of batches to propose suitable models for future operations and to ascertain costs and margins for different models and formats.

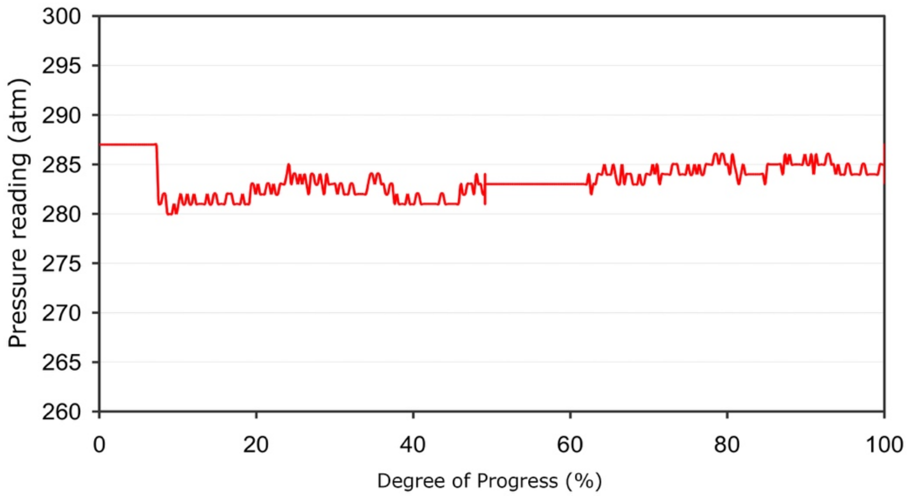
Let us now consider another aspect which, in our view, is of no less interest. Let us evaluate "a posteriori" why significant quality deviations occur in certain batches compared to others. This analysis builds on those variables considered to be essential in the process - our pilot, which is going to be compared to actual manufacturing data, highlights pressure in the press and firing profile. In a real-life scenario, any variables considered to be appropriate can be added. In the pilot, a significant deviation is seen in OF 0042, with a drop in first-grade and a sharp rise in second-grade.

Firing start date	Manufacturing order	Energy cost batch (€/m²)	Raw materials costs (€/m²)	First grade	Second grade	Bargain	Margin (€/m²)	Output (m²)	Deviation from model (€)	Pressure	Pressure deviation	Av. peak firing temp.	Deviation from peak firing temp
07/02/2014	OF0042	75,52	2,36	71,4	27,5	1,1	1,99	8184	4206	278	1	1183	9
19/03/2014	OF122	77,58	2,42	90,5	8,4	1,1	2,49	3169	538	278	2	1185	2
20/03/2014	OF124	79,88	2,38	96,5	0,1	3,3	2,62	2665	120	279	3	1184	3
21/03/2014	OF126	79,51	2,53	86,6	11,3	2,1	2,21	754	187	279	1	1185	1
18/04/2014	OF170	76,70	2,44	66,5	22,4	11,1	1,46	2058	1265	269	10	1182	12
19/04/2014	OF172	78,69	2,37	89,3	7,5	3,2	2,43	1326	213	278	2	1186	2
23/04/2014	OF176	77,17	2,42	95,4	1,4	3,2	2,58	5052	524	278	1	1185	3
01/05/2014	OF186	75,83	2,29	94,5	2,2	3,3	2,69	4427	5	278	1	1185	2
03/05/2014	OF188	74,75	2,49	95,5	2,5	2,1	2,56	5895	731	280	2	1185	1
08/05/2014	OF193	74,99	2,43	96,4	0,2	3,3	2,61	1232	0	279	1	1183	1
							TOTAL	34763	7791				

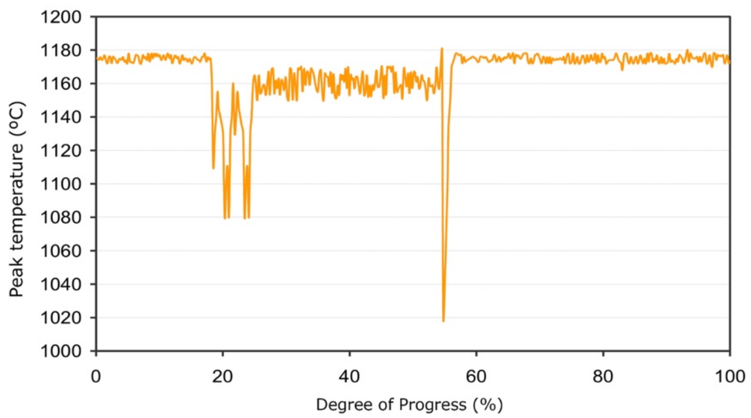
Given that we have the data for the batch variables, including how the classification has evolved depending on what we have called Degree of Progress, calculated by counting the square metres in the production batch, it is possible to narrow down when such deviation occurred.



Once the point where the deviation in quality occurred has been delimited, the next step is to look at how the key variables evolved during that period of time. In the pilot, we looked at pressure, where we found no significant deviation.



However, an assessment of peak firing temperature shows it to be the most likely cause of the deviation in quality.



4. CONCLUSIONS

We have developed a pilot scheme which is being implemented at the aforementioned **Azulejera Alcorense** industrial plant. We will run the pilot scheme in the real conditions specified to us by the management, by adjusting our premises to the specifications to be met in this case in order to determine its validity from the technical point of view and its ability to forecast economic incentives.

Therefore, it will provide:

- **Individual split per production batch** and access to the corresponding process data.
- A calculation of the **cost and net margins** attributable to each batch.
- **Benchmark standards** that identify the best in terms of economic margin.
- When **significant quality deviations** occur, the ability to **trace** and identify the likely operating variables that cause them.
- Cost identification and the chance to establish balances between **cost and quality**.

To achieve all of that, we are using the information provided by them to draw up a specification for roll-out that includes:

- The technical specifications required to collect data in the various process stages.
- The digital infrastructure needed.
- The operating variables required.
- The specific calculations needed.
- A real estimation of incentives.

Naturally, we are still at a preliminary stage but a simple outline of the incentives to be gained based on actual manufacturing data showed:

- **€1,000,000** for 5,000 m^2/day from improved Gross Margin
- **€300,000** from formats and models that generate higher gross margin,

which enables us to infer the enormous potential this technology offers when applied correctly.

As a final summary, we are proposing a change of culture to bring **digitisation** into the operations, which to date has only been applied in Finance (ERPs).